An adaptive multi-agent architecture for workplace integration

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Abstract. This paper presents a prototype for adapting workplaces for disabled people. The effective integration of people with disabilities in the workplace is a huge challenge to society, and it presents an opportunity to make use of new technologies. The project, called AZTECA, aims to develop new tools that contribute to the employment of groups of people with visual, hearing or motor disabilities in office environments. These different tools for the disabled people have been modelled with intelligent agents that use Web services. These agents are implemented and deployed within the PANGEA platform so that PANGEA conforms the skeleton of the system and allows developing an integrated system. The main target of the prototype presented in this paper is the people detection using ZigBee technology and the personalization of the workplace according to the users disability.

Keywords: personalization workplace; disabled people; open multi-agent system; agent platform; ZigBee; proximity detection; localization.

1 Introduction

In recent years, due to technological advances, intelligent systems have become an important part of our lives. These systems can be found in multiple places, and providing a huge range of facilities. One of these facilities is personalization, as in the case of the publicity. In addition, disabled people face increasing difficulties in their workplaces. Most of the workplaces are not adapted to their disabilities, so they find barriers which cannot overcome alone. Thanks to these new intelligent systems, disabled people are able to overcome difficulties they find when performing their work successfully. Workplace customization will facilitate labour inclusion of people with disabilities. In this paper we present a workplace customization prototype. The rest of the paper is structured as follows: the next section discusses the technologies for localization systems and introduces open multi-agent system. Section 3 details the proximity prototype system, as well as the agent platform used for its design and its integration. Section 4 explains our case study involving disabled people and finally, in section 5 some conclusions are presented.

2 Background

In this section, we discuss the state of art of the different multi-agent systems that could be used for our prototype. In addition, technologies that could be used for indoor localization of disabled people are presented. They will serve as a background for the architecture we will propose.

2.1 Open multi-agent system

Nowadays, there are many multi-agent frameworks, which help and facilitate to work with agents [1] [10] [7] [5]. The main drawback of these systems is that they are for general purpose. General purpose was consider as a major issue twenty years ago, but it is much less the case now, at a time where personal computers, devices, mobile phones and alike, have exponentially grown. In addition, the needed architecture must be able to assume the tasks for the integration of disabled people in their workplaces. And difficulties from one disabled people to another are very different. Some most known European multi-agent systems projects oriented in our research di-rection are:

- CommonWell [2] proposes architecture to support European citizens with limited mobility, or hearing or visual impairment. However, it focuses on the elderly and does not incorporate either advanced adaptive interfaces or identification and localization elements.
- DTV4A11 [3] proposes the use of digital television to integrate persons with disabilities, but it relies on the television as the only mechanisms to provide services.
- MonAMI [17] proposes a global framework to offer services to the elderly and handicapped people, but it focuses on providing these individuals only with a more independent lifestyle.

At a Spanish national level, we can also find the following relevant frameworks:

- DISCATEL [4] aims to incorporate persons with disabilities to Contact Centers or to allow them to telecommute from their home or residence.
- INREDIS (INterfaces for the RElationship between people with DISabilities) [13] is a CENIT project headed by Technosite, which investigates the concept of using personal devices with interoperability and ubiquitous characteristics to strengthen accessibility of disabled people.

- The eVia platform involves the INCLUTEC [12] study group, and is oriented toward analysis. It promotes the use and development of mobility mechanisms such as assisted wheelchairs and specialized vehicle, alternative and enhanced communication, manipulation, and cognition.

None of these multi-agent platforms can really adapt to our requirements because most of them focus on the elderly themselves or on the social integration of disabled people, but none of them addresses the inclusion of the disabled people in their workplaces. This is the reason why we have developed the PANGEA platform. The novelty of PANGEA is its dynamic and adaptable nature; it integrates new services for including peolple with visual, hearing or mobile impairments into the workforce.

2.2 Technologies for localization systems

Localization systems enable to localize and identify people or other elements whatever is their environment. They are composed of two elements: sensors and tags. Tags are found in the elements to be localized, while sensors are usually placed in fixed locations, thus generating a sensor network that can localize different devices. There are currently different localization systems, depending of the type of technology that is used. Among the different available alternatives, one can find:

- GPS: a GPS system is based on the localization through a group of satellites, which are continuously sending information. Mobile devices collect the information. These receivers calculate the positions based on the satellite coordinates and triangulation. The more satellite references there are available, the greater the precision in calculating locations.
- GSM/GPRS: Mobile phone operators also offer localization services. They function by using the antenna network of the telephone service. The localization is made through the mobile device or the service provider since both the antennas and the devices are both transmitters and receivers. The localization is calculated by using parameters such as signal time reception, angles of incidence, and triangulation of signals or relevant cells.
- RFID: Radio Frequency Identification Technology (RFID) is an alternative used to develop real time localization systems. It functions through a network of readers and RFID tags [19]. An RFID system is essentially composed of four elements: tags, readers, antennas and radios, and processing hardware [8].
- Wi-Fi: Localization systems based on Wi-Fi [16] use devices from wireless networks to calculate position. A mesh of nodes (transmitters and fixed receivers) that function as a reference for mobile nodes. The system calculates the position of the mobile nodes using the signals received by the fixed nodes.
- Bluetooth: This technology works, as Wi-Fi does, in the 2.4 GHZ ISM (Industrial, Scientific and Medical) band. It can be used to build RTLSs (Real-time Locating Systems), based on RSSI (Signal Strength Measurement) measurements. Like Wi-Fi, it also uses localization techniques such as signpost,

fingerprinting or trilateration. The main drawback that invalidates this technology for our concern is the difficulty in building WSNs made up of more than 8 devices [11].

- ZigBee: it is a low-cost, low-power consuming, two-way wireless communication standard developed by the ZigBee Alliance [20]. It allows operating in the ISM band and addresses 2.4GHz almost all over the world. The underlying IEEE 802.15.4 standard is designed to work with low-power limited resources nodes [9]. ZigBee adds network and application layers over IEEE 802.15.4 and allows more than 65,000 nodes to be connected in a mesh topology WSN.

For our workplace inclusion purpose, among this list of possible technologies for our prototype, we remove the GPS technology, since its usage is limited to outdoor places, making its indoor used impossible. We also remove GSM technology because its lack of precision. Viable technologies options are then in fact restricted to Wi-Fi and ZigBee. On the one hand, Wi-Fi technology has a low cost of infrastructure, but its precision is lower than a ZigBee system; since we need a high precision level, we choose ZigBee as the technology for the realization of our prototype. As an additional argument, ZigBee is designed to be embedded in consumer electronics, home and building automation, industrial controls, PC peripherals, medical sensor applications, toys and games, and it is intended for home, building and industrial automation purposes, which perfectly addresses the need of monitoring, control and sensory network applications [20].

3 System Overview

The proximity detection system is based on the detection of presence using ZigBee. Every computer in the room must have a ZigBee router assigned, and the system has to know their exact positions at every moment. Furthermore, all the users have to carry a ZigBee tag that is responsible for identifying each of them. Once the ZigBee tag carried by the person has been detected and identified, its location is delimited within the proximity of the sensor that identified it. The RSSI (Received Signal Strength Indicator) parameter is the responsible of measuring the receiving signal strength. The value fluctuates from an initial 0 to negative values. If the value is close to 0, the user tag is near a computer. If the user moves away from the workplace, the value starts to be negative. To handle this behaviour, we have developed an algorithm based on the RSSI parameter. We have identified 5 levels in the scale. If RSSI is greater or equal than -50, the algorithm increases one level. If the value is lower than -50, the algorithm decreases one level. When the maximum number of levels has been activated, the system understands that the user is within the proximity distance and that the user wants to use her computer. As a consequence, the profile associated to the tag which is specific to the users disability is activated and the computer is remotely switched on. Reaching the initial level of 0 means that the user has moved a significant distance away from his workplace, and that the computer should be turned off. For switching on the computers, since the system uses a LAN infrastructure, we use the wake-on-LAN protocol. The wake-on-LAN/WAN technology allows a computer to be remotely turned on by a software call. It can be implemented in both Local Area Networks (LAN) and Wide Area Networks (WAN) [15]. It permits several usages, including turning on a Web/FTP server, remotely accessing files stored on a machine, telecommuting, and in this case, remotely turning on a computer when it is turned off [18]. Finally, we will also use an open multi-agent system implemented with PANGEA that will gather all agents and information needed to develop an integral system that will assist disabled people in their workplace. The structure of such open multi-agent system may evolve over time, its components are not known a priori, they may be heterogeneous and they also may evolve differently. The open multi-agent system should allow dealing with heterogeneous agents, and even with agents written in different languages. This makes it difficult to rely on the agents' behaviour, and requires a social control based on societal norms/rules.

3.1 Description of PANGEA

PANGEA is a service-oriented platform that allows the open multi-agent system to take maximum advantage of the distribution of the resources. To this end, all services are implemented as web services. Due to service orientation, different tools modelled with agents that consume web services can be integrated and operated from the platform, regardless of their physical location or implementation. This makes it possible for the platform to include both a service provider agent and a consumer agent, emulating client-server architecture. The ProviderAgent (a basic agent that provides a service) knows how to contact the web service, while the remaining agents know how to contact with the ProviderAgent due to their communication with the ServiceAgent, which contains information about the available services. Once the ClientAgents request has been received, the ProviderAgent extracts the required parameters and establishes the contact. Once the contact is established, the results are sent to the client agent. Using Web Services also allows the platform to introduce the Service-Oriented Architecture (SOA) [14] into multi-agent system systems. SOA is an architectural style for building applications that use services available in a network such as the web. It promotes loose coupling between software components so that they can be reused. Applications in SOA are built based on services. Running PANGEA, the platform automatically launches the following agents:

- OrganizationManager: this agent is responsible for the actual management of organizations and suborganizations. It is responsible for verifying the entry and exit of agents, and for assigning roles. To carry out these tasks, it works with the OrganizationAgent, which is a specialized version of this agent.
- InformationAgent: this agent is responsible for accessing the database containing all pertinent system information.
- ServiceAgent: this agent is responsible for recording and controlling the operation of services offered by the agents.

– NormAgent: this agent ensures compliance with all the refined norms in the organization.
– CommunicationAgent: this agent is responsible for controlling communication among agents, and for recording the interaction between agents and or-ganizations.
– Sniffer: manages the message history and filters information by controlling communication initiated by queries.

3.2 Integration of the agents of the detection prototype within PANGEA

The platform agents are implemented with Java, while the agents of the detection prototype are implemented in .NET and nesC [6]. the following figure presents the system's architecture:

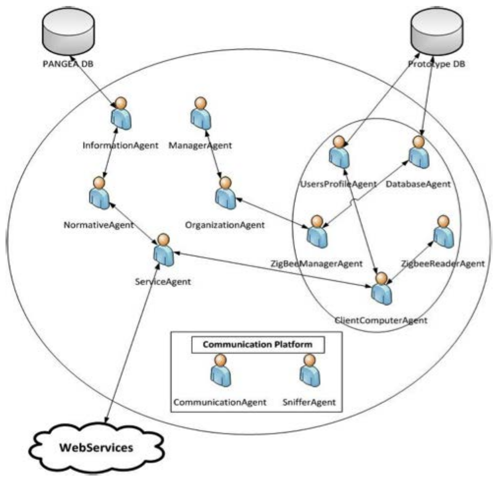

Fig. 1. System architecture

Interactions between the different kinds of agents can be seen in 1:

– ZigBeeManagerAgent: manages communication and events. It is deployed in the server machine.
– UsersProfileAgent: is responsible for managing user profiles. It is also deployed in the server machine.
– ClientComputerAgent: these are user agents located in the client computer. They are responsible for detecting the users presence with ZigBee technology, and for sending the users identification to the ZigBeeManagerAgent. They manage the strength of the signal in order to determine how close or

how far the user is. These agents are responsible for requesting the profile role adapted for the user to the ProfileManagerAgent when the users equipment needs to be turned on and personalized. Each ClientComputerAgent is localized in a piece of office equipment (computer).
- DatabaseAgent: the detection proximity system uses a database that stores data related to the users, sensors, computer equipment and status, and user profiles. It can also communicate with the InformationAgent of PANGEA.
- ZigBeeCoordinatorAgent: is included in the ZigBee device. It is responsible for coordinating the other ZigBee devices in the office.
- ZigBeeReaderAgent: these agents are included in several ZigBee devices that are used to detect the presence of a user. This agent is responsible for managing the personalized information for each user.

In the next section, an example of how these agents interact each other to customize the system is shown. Furthermore, it explains in more detail the parameters and technologies used and the devices involved in the case study.

4 Case Study

This paper presents a proximity detection system used by disabled people to facilitate their integration in workplaces. The main goal of this system is to detect the proximity of a person to a computer using ZigBee technology. For this, the main value used, as explained in previous sections, is the Signal Strength Measurement (RSSI). Thus, once the user is detected, the system can automatically switch on/off the computer, identify the user profile and load it, launch applications, and adapt the workplace to the specific needs of the user. As a result of the ZigBee technology, the prototype is notably superior to existing technologies using Bluetooth, infrareds or radiofrequencies, and is highly efficient with regards to detection and distance. The following table shows a comparison regarding bandwidth, frequency and coverage.

Table 1. Comparison Wireless Techonologies

	Bluetooth	RFID	NFC	ZigBee
Bandwidth	800 Kbps	Varies	106/212/424 Kbps	250 Kbps
Frequency	2.4 GHz	Varies	13.56 MHz	868 MHz, 2.4 GHz, 915 MHz
Coverage	10 meters	3 meters	10 cm	30-100meters

User profiles store data related to applications that are useful to users. These data can be classified according to the application, as shown in the following table.

As it can be seen, the system stores in user profiles the parameters related with the use of the computer such as the cursor speed, the magnification or the colours. All this is configurable in the prototype, which can be adapted to future users having different preferences. Additionally, different types of situations in

Table 2. Users Profiles Stored

Screen		
Parameter	Value	Description
usage	Preferred/unpreferred	Field to describe if this tool is used.
invertColourChoice	1/0	Field to describe if the colors are inverted.
magnification	1-200	Field to describe the level of magnification the user want on the screen.
Narrator		
Parameter	Value	Description
usage	Preferred/unpreferred	Field to describe if this tool is used.
speechRate	1-10	Field to describe the speed of narration.
volume	1-10	Field to describe the volume level of the tool.
Language		
Parameter	Value	Description
language	ISO 3166-1 alfa-3	Field to describe the user's language.
Virtual Keyboard		
Parameter	Value	Description
usage	Preferred/unpreferred	Field to describe if this tool is used.
Head Mouse		
Parameter	Value	Description
usage	Preferred/unpreferred	Field to describe if this tool is used.
cursorAcceleration	1-10	Field to describe the accelerating the cursor.
cursorSpeed	1-10	Field to describe the speed of the cursor.

a work environment have been taken into account, including nearby computers, shared computers, etc. Our case study includes a distribution of computers and laptops in a real office environment, distant by 2 meters. The activation zone is approximately 90cm, a distance considered as close enough to be able to initiate the activation process. It should be noted that there is a sensitive area in which it is unknown exactly which computer should be switched on: two computers being in close proximity may impede the systems efficiency from switching on the desired computer. The experiments have shown that the optimal distance separating two computers should be at least 40cm.

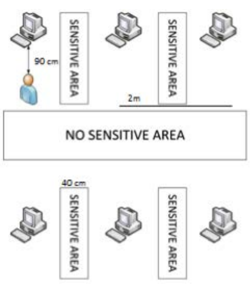

Fig. 2. Distribution of computers in the Case Study

Figure 2 shows a diagram in the case of our prototype. The prototype will be implemented in an office at our institute. The system will be installed in every computer in the workplace; so, users could use the one they want. Every user

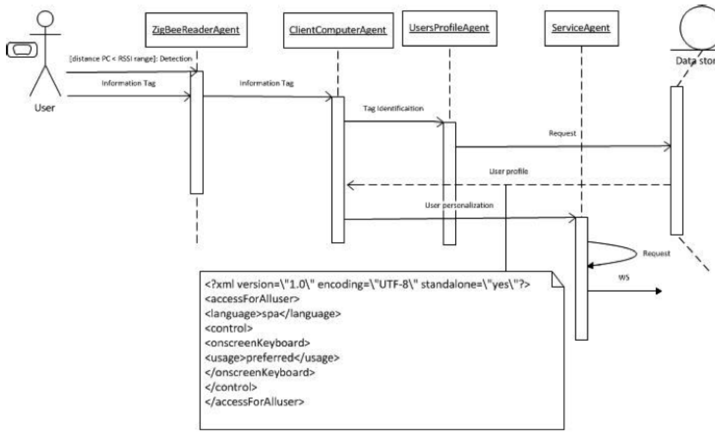

Fig. 3. Request sequence diagram

in the proposed system carries a ZigBee tag, detected by a ZigBeeReader-Agent located in each system terminal and is continuously in communication with the ClientComputerAgent. Thus, when a user tag is sufficiently close to a specific terminal (within a range defined according to the strength of the signal), the ZigBeeReaderAgent can detect the user tag and immediately send a message to the ClientComputerAgent. Next, this agent communicates the tag identification to the UsersProfileAgent, which consults the database to create the XML file that is returned to the ClientComputerAgent. The ClientComputerAgent finally interacts with the ServiceAgent to invoke the Web Services needed to personalize the computer according to the users profile. The figure 3 presents a sequence diagram that shows the interaction between the agents involved in a case of user detection by the prototype. The note of the sequence diagram shows an example of XML used to identify the user profile.

5 Conclusions

The prototype that has been described provides a multi-agent system that is able to communicate with a proximity detection system and that personalizes the workplace improving the companys workflow. The individual adaptation allows that, whatever is the disability of the person, the workplace will be adapted to him automatically. This will increase his productivity by removing the current barriers he usually has to face. One example of turning on the computer using a proximity detection system has been shown. Thanks to the SOA architecture of PANGEA, the system is high scalable. Some of future services that will be embedded include pointer services, predictive writing mechanisms, adaptation for alternative peripheral, virtual interpretations in language of signs, identification of objects by means of RFID, etc.

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